# PRIMARY VERIFICATION: IS THE TRISS APPROPRIATE FOR THAILAND?

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**Abstract**. The Trauma and Injury Severity Score (TRISS) is a well-accepted model used to evaluate the quality of trauma care in the US. This research aims to study whether TRISS can be applied to evaluate trauma care and classify outcomes of road traffic injury patients in Thailand. A retrospective study was used to review the Thailand's Injury Surveillance System database from the 1st January to the 31st of December 1996. The study subjects were severe road traffic injury patients with blunt injuries. The TRISS model was applied to compute the survival probability for each patient. The chi-square goodness-of-fit was used to compare the survival probability distribution between the American Major Trauma Outcome of Study (MTOS) and the road traffic injuries in Thailand. The accuracy, sensitivity and specificity of the survival prediction by TRISS were evaluated. The distribution of survival probability between American trauma patients and Thai road traffic injury patients was significantly different (p-value<0.00001). The TRISS model had high accuracy and sensitivity, but low specificity, in predicting the survival of Thai road traffic injuries. The MTOS and Thai road traffic injuries had different distributions for various factors such as the Revised Trauma Score (RTS), Injury Severity Score (ISS), and ages which effect injury survival. Due to these factors the distribution of survival probability between MTOS and Thai road traffic injuries was also significantly different. By applying TRISS, the survival prediction of Thai road traffic injuries resulted in a high number of false positives.

## INTRODUCTION

Since 1982, survival probability has been recommended as a tool to evaluate trauma care. In the past decade many different survival probability models were developed to predict outcome (survival/death) of trauma patients. One of these models is the Trauma and Injury Severity Score (TRISS), which was introduced, developed and validated by Champion *et al* (1990). The model included both anatomic and physical criteria, using logistic regression techniques to predict the survival probability of trauma patients based on the Revised Trauma Score (RTS), Injury Severity Score (ISS), the mechanism of injury (blunt/penetrating) and the age of the patient. These parameters were used to calculate survival probability and provided guidelines on how to improve the quality of hospital care. The TRISS model was utilized in two different evaluation methods. The first is a PRElination evaluation, which is a mean to support quality assurance activity, for instance if the survival probability of the injured patient is predicted by TRISS model to be >0.5 but the patient dies (unexpected outcome), then it is worthwhile for the physician to investigate the reasons for the unexpected outcome and review the cause of death of this patient. The other, the DEFinitive evaluation, is a statistical method used to compare the outcomes (survive/death) from the hospital with the baseline standard (MTOS) of the patients (Champion *et al*, 1990).

The TRISS model was developed for use in the US. This model should only be applied in the area where the data were collected, or in the area

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which has the same survival probability distribution with the MTOS database. It would be incorrect to apply the TRISS model to a situation in other areas or areas with different survival probabilities. Survival probability models should be adjusted to the situation in a given model and can only be applied as it is in the country which has the same survival probabilities under the assumption that the variables of the TRISS model are also equivalently meaningful to evaluate the trauma care outside of the US (Jones *et al*, 1995).

A method was proposed to examine the similarities of survival probabilities between MTOS and the new data set. This M statistic is recommended to compare these survival probabilities (Boyd *et al*, 1987). However, the M statistic does not follow any statistical distribution. The M statistic is not a formal statistical test for assessing the significant difference between two survival probability distributions. (Jones *et al*, 1995). However it is useful in revealing gross differences in injury mix but does not measure the direction of injury severity mismatch (Hollis *et al*, 1995). Jones *et al* (1995) recommended the chi-square goodness-of-fit test as a useful tool to compare the distributions of survival probability between the MTOS and the new data set.

In the past decade, trauma has become a leading cause of morbidity and mortality in Thailand, as well as in other developing countries. Since it is one of the most important causes of premature death, besides prevention programs, improving the quality of care for trauma patients and preventable deaths are the main goals of medical care. The Epidemilogy Division of the Ministry of Public Health (MOPH) has established an injury surveillance system, which aims to set up a database for assessing the quality of acute care and interfacility transfer provided to the injured by the hospital at a provincial level, and also to facilitate injury prevention and control. A trauma registry form was modified to accommodate all injuries from external causes of morbidity and mortality (except complications from medical and surgical care) and was used as record form. The TRISS methodology was available in the software of this injury surveillance system. The survival probability estimate by TRISS was promoted by the Epidemiology Division to be used as screening tool for identifying trauma cases with unexpected outcomes. Trauma audits should be done on screened cases and to improve the quality of acute trauma care (Santikarn *et al*, 1999). To accurately estimate the survival probability of the Thai trauma patient, a model from the data collected in Thailand should be developed.

This study aims at testing the TRISS model in Thailand using a database of road traffic injured patients derived from various provinces in the country.

## MATERIALS AND METHODS

### Injury Surveillance System

Data from the Injury Surveillance System in Thailand was used in this retrospective study. The MOPH initiated the system in 1993. Actual registration and the setting up of the database started in 1995. At the start, data were collected voluntarily from 5 participating provincial hospitals. At present, about 20 hospitals are contributing to the system. A hospital contributing to the Injury Surveillance System must fulfill the following criteria: the hospital must have at least 500 beds, and it must be in the position to participate continuously in the system.

All injured patients admitted to the Emergency Department (ED) were included in the database. Also registered, were those patients with injuries occuring within 7 days of admission to the hospital and those persons who died before arrival at the ED. Information on the injured patients was entered into an Injury Surveillance Form. The Injury Surveillance Form included demographic data of the patient (age, sex, and occupation); time and place of injury occurrence; how the patient was transferred to the hospital; kind of first-aid and pre-hospital care given during referral; time of admission and discharge from hospital; type of injured patient; alcohol consumption and use of safety devices. Nurses at the provincial hospital (at the ED) recorded the severity of the injury, final diagnosis based on the Abbreviate Injury Severity Score (AIS-85), and the type of injury (blunt/penetrating). Initial vital signs upon admission to the ED, namely the respiratory rate (RR), the systolic blood pressure (SBP), and the Glasgow Coma Score (GCS), as well as

outcome upon discharge (survival/death), were also included in the Injury Surveillance Form.

The data were coded by registration officials in the provincial hospitals who were trained to record and code data on the Injury Surveillance Form; entered into the dBASE software data file, and submitted to the MOPH in Bangkok. The Injury Surveillance System is explained in more detail elsewhere (Santikarn *et al*, 1999).

**Study subjects**

Subjects for this study were road traffic injured patients registered under the Injury Surveillance System from the 1st January to the 31st December 1996. The subjects were from 7 provincial hospitals in Thailand. The selection criteria for the study subjects were: severity of cases (death on arrival at ED or admission to ward); age (15 years and above); and completeness of data (GCS, SBP, RR, type of injury, AIS-85, age and discharge outcome). The STATA version 6.0 was used for statistical analysis of the data collected.

**Methods**

The TRISS model, as previously described (Boyd *et al*, 1987; Champion *et al*, 1990) combines age, physiological and anatomical characteristics to estimate survival probability by the following model equation:

$$Ps = 1/(1 + e^{-b})$$

where:

$b = b_0 + b_1(RTS) + b_2(ISS) + b_3(Age)$, and Ps is the survival probability of a patient with the coefficients RTS, ISS and Age.

The RTS is a physiological index of injury severity assessed on arrival at a hospital. It is a weighted sum of coded values of the Glasgow Coma Score (GCSc), systolic blood pressures (SBPc) and the unassisted respiratory rate (RRc) as presented in Table 1. These assigned weights are derived from a regression analysis of the patients in MTOS. The RTS range is 0-7.8408. High values are associated with improved prognosis. The RTS equals 0.9368 (GCSc) + 0.7326 (SBPc) + 0.2908 (RRc) (Champion *et al*, 1990).

The ISS is the anatomic indicator for overall severity of injury. It is the sum of the squares of the highest AIS-85 score in the three most severely injured body regions ranging from 1-75. High values are associated with a worse prognosis.

Table 1
Revised Trauma Score variables.

| Glasgow coma scale | Systolic blood pressure (mm Hg) | Respiratory rate (min) | Code value |
|---|---|---|---|
| 13-15 | > 89 | 10-29 | 4 |
| 9-12 | 76-89 | > 29 | 3 |
| 6-8 | 50-75 | 6-9 | 2 |
| 4-5 | 1-49 | 1-5 | 1 |
| 3 | 0 | 0 | 0 |

Source of data: Champion *et al* (1990).

Table 2
Coefficients of the TRISS model.

| Type of injury | $b_0$ | $b_1$ (RTS) | $b_2$(ISS) | $b_3$(Age) |
|---|---|---|---|---|
| Blunt | -1.2470 | 0.9544 | -0.0768 | -1.9052 |
| Penetrating | -0.6029 | 1.1430 | -0.1516 | -2.6676 |

Source of data: Champion *et al* (1990).

The patient's age is coded as 0 if the age is <55 years and age = 1 if the age is ≥55 years.

The b's are coefficients of the TRISS model derived from a logistic regression analysis of the MTOS and they differ according to the type of injury (Table 2) (Boyd *et al*, 1987; Champion *et al*, 1990).

The method used to verify whether the TRISS model is applicable to road traffic injury in Thailand is the comparison of survival probability distribution of the MTOS and Thai injuries data set. The survival probability of MTOS computed by the TRISS model, classified into six intervals and calculated for survival probability fractions (Boyd *et al*, 1987; Jones *et al*, 1995). The TRISS model was also applied to a set of study subjects from Thailand. The observed number of Thai injuries was obtained by computing survival probability for each patient and classi-

fied into six intervals. The expected numbers were obtained by converting the MTOS survival probability fraction into the number of Thai patients. This procedure is conventionally called the standardization. If the proportion of both groups of patients, *ie* from the US and Thailand are the same, then based on the US patients, the $\chi^2$ test was used to test the difference between the expected and observed Thai positives in order to judge the usefulness of the TRISS model to the situation in Thailand. The chi-square goodness-of-fit test was used to compare the distribution of the survival probability of MTOS and Thai road traffic injuries (Jones *et al*, 1995).

$$\chi^2 = \sum_{i=1}^{6} \frac{(Oi-Ei)^2}{Ei}$$

where:

$O_i$ is the number of observed and $E_i$ is the number of expected survival events of Thai road traffic injuries, for interval i.

In the TRISS model, the survival probability of a single patient varies between 0 and 1. In order to test how accurate the model is in predicting the survival of Thai injured patients, the survival probability of this model used a cut-off value of 0.5. The cut-off value of 0.5 was used to predict the survival of patients whose survival probability exceeded the cut-off value, and non-survival if the survival probability was less than the cut-off value. The validity of the TRISS model was indicated by sensitivity (proportion of survivors correctly allocated), specificity (proportion of death correctly allocated), and accuracy (proportion of patients correctly classified over all) (Jones, 1995).

Sensitivity = TP/ Total survival
Specificity = TN / Total death
Accuracy = TP + TN / Total subjects

where:

TP is the number of patients expected to survive according to the model and TN is number of patients expected to die according to the model.

## RESULTS

From the 1st January to the 31st December 1996, 15,762 severe road traffic injuries were recorded. From these, 8,599 patients satisfied the criteria as study subjects. Of these, 8,477 (98.58%) of the study subjects were patients with blunt injuries. Only 122 (1.42%) patients had penetrating injuries. Among those having penetrating injuries, 2 (1.64%) deaths were recorded. Because of the small number of patients suffering from penetrating injuries, this study concentrates only on patients with blunt injuries.

From the 8,477 patients with severe blunt injuries, 484 (5.71%) deaths were recorded. The TRISS model for a blunt injury was applied to a set of study subjects from Thailand. The observed number of Thais with blunt injuries was obtained by computing the survival probability for each patient and classified into six intervals as presented in Boyd *et al* (1987). The expected numbers were obtained by converting the MTOS survival probability fraction into the number of patients multiplied by 8,477. Analysis of the observed and expected numbers of Thai road traffic injuries falling into the six intervals shown in Table 3, gave a significant chi-squared value (554.512 at 5 df, p-value < 0.00001).

When comparing the characteristics of Thai road traffic injuries with MTOS injured patients in the US, it was interesting to determine how the distribution of the factors related to survival probability differ between MTOS and Thai injury patients. Table 4 shows the summary data for 15,612 severe Thai road traffic injuries and 142,104 American MTOS with blunt injuries. The American trauma patients tend to be more severely injured than the Thai trauma patients according to RTS and ISS indicators. A comparison of age showed that a larger percentage of people aged 55 years and above were injured in America while injured patients in Thailand were younger. Hence, the indicators of severity and age of road traffic injury patients admitted to the participating provincial hospitals in Thailand differ from MTOS injury patients in the US. The survival probability of each of the 8,477 injuries was calculated using the cut off point at 0.5 to define predicted survival and death. Table 5 shows the classification of the TRISS model having a high proportion of patients correctly classified over all, a very high proportion of survivors correctly allocated (96%, 99%), but a low proportion of death clas-

Table 3
Comparison of the distributions of the probability of survival between American MTOS and road traffic injuries in Thailand following the application of the TRISS model for blunt injuries.

| Survival probability interval | Fraction of MTOS patients[b] | Number of admissions | | Contribution to chi-square $(O_i-E_i)^2/E_i$ |
|---|---|---|---|---|
| | | MTOS distribution (expected) E[c] | Thai road traffic injuries (observed) O[d] | |
| 0.00-0.25 | 0.035 | 297 | 94 | 138.751 |
| 0.26-0.50 | 0.017 | 144 | 65 | 43.340 |
| 0.51-0.75 | 0.029 | 246 | 125 | 59.516 |
| 0.76-0.90 | 0.044 | 374 | 140 | 146.406 |
| 0.91-0.95 | 0.045 | 382 | 223 | 66.181 |
| 0.96-1.00 | 0.828 | 7,033 | 7,830 | 90.318 |
| Total | 1.00 | 8,476 | 8,477 | 544.512[a] |

[a]Chi-square = 554.512 (df=5) p-value<0.00001.
[b]Source of data is Boyd *et al* (1987); Jones *et al* (1995).
[c]These fractions were converted into the numbers of the expected values of patients were obtained by multiplying the fraction (column 2) by 8,477, Thai road traffic injuries with blunt trauma.
[d]The observed numbers of patients were obtained by computing the probability by TRISS model.
MTOS is Major Trauma Outcome of study database.

sification correctly assigned (31%).

## DISCUSSION

There is a significant difference in the distribution of survival probability between the Thai and American traumatic patients. The TRISS model predicted survival of road traffic injury patients in Thailand with a high rate of false positives, as indicated by the low specificity of the model. It is concluded that the TRISS model might be inappropriate for evaluating the quality of trauma care in Thailand.

At start, the MOPH of Thailand would like to use the TRISS model to compare the quality of trauma care between Thai hospitals and US level 1 trauma centers. Thailand's data is not applicable to the TRISS model (as shown by the statistical differences between the O and E values) which might be due to the difference in severity and age of the patients. The TRISS model gives high false positive rates (the prediction was for survival but the patients did not survive). For any clinical diagnostic test, if the value of classification of any test is less than 50%, the model is not a good tool to predict the outcome (Fletcher *et al*, 1982). Therefore the MOPH can not make any conclusions as to the differences in the quality of trauma care in Thai and US trauma centers.

In this data set, the overall severity of road traffic injuries in Thailand was lower than the MTOS database, probably because of different factors related to the survival of injuries. There were many factors related to the severity of injury, which affect injury survival. The factors, which can reduce the severity of injuries are pre-hospital care, safety device regulations, anti-drunk-driving laws and speed limitation. These programs have been implemented by the MOPH and by the Thai government but they have yet to be successfully enforced. Thus the severity of road traffic injuries would be worse than in the US, consequently the most severe injuries died at accident scene. In Thailand, pre-hospital care of trauma patients is not sufficient and in some places is not available. In some small hospitals in Thailand an Emergency Medical Service (EMS) is not capable of treating trauma victims. Trauma care equipment and staff may not be available or not adequate to take proper care of such patients. Those severe injuries are often referred from accident scenes or small hospitals to the nearest pro-

Table 4
Comparison of the characteristics of American MTOS and Thai road traffic injuries with blunt injury emergency department admissions.

| | MTOS[a] | Thailand |
|---|---|---|
| Number of patients | 142,104 | 15,612 |
| Revised Trauma Score | | |
| <7.84 | 23.3% | 18.33% |
| 7.84 | 66.2 | 65.35 |
| Not known | 10.5 | 16.30 |
| Injury Severity Score-85 | | |
| 1-8 | 37.2% | 61.06% |
| 9-15 | 34.0 | 23.39 |
| ≥16 | 28.5 | 14.36 |
| Not known | 0.3 | 1.19 |
| Patient age | | |
| <15 | 12.2% | 11.64% |
| 15-54 | 67.4 | 80.82 |
| ≥55 | 20.2 | 7.53 |
| Not known | 0.2 | 0 |
| Cause of injury | | |
| Road traffic accident | 61.0% | 100% |
| Fall | 22.6 | 0 |
| Other | 16.2 | 0 |
| Not known | 0.2 | 0 |
| Patient sex | | |
| Male | 65.5% | 77.05% |
| Female | 33.9 | 22.93 |
| Not known | 0.6 | 0.02 |

[a]Source of data: Jones *et al* (1995).

Table 5
Accuracy, sensitivity and specificity proportions of the TRISS model to predict survival of severe road traffic injuries with blunt trauma in Thailand.

| Accuracy(%) | Sensitivity (%) | Specificity(%) |
|---|---|---|
| 96.02 | 99.93 | 31.40 |

vincial hospitals, some of them die during transfer. These can be considered as one of the main causes for the loss of lives of many severely injured patients before arrival at the ED of provincial hospitals. Thus most of the injured patients who were able to reach the provincial hospital alive were less severe cases than trauma victims who died at the scene or during transfer.

Among severe road traffic injuries who were admitted to the ED, a large proportion of of them were accidents caused by motor cyclists, who are, on average, younger than car drivers. Hence, the Thai's injured patients were less severe and younger in the ED of provincial hospitals. The low averages of severely injured and younger patients due to the above mentioned reasons affects the distribution of survival probability. These main causes would affect the validity classification (high false positive rate) of the TRISS model, which was based on more severe cases and older ages of patients.

There are some reasons for the high false positive rate of survival when applying the TRISS model to Thai injuries. The TRISS model was constructed for all kinds of injuries (*eg* fall, assault, etc), but in this study the TRISS model is applied to only to the subgroup, road traffic injuries. Those other causes of injury might have factors related to survival that are different from those for road traffic injuries (*eg* the road traffic injuries had higher numbers of head injuries than other causes of injury so physical indices are of more importance to the prediction of survival of road traffic injuries than to other causes of injury). It is more valid to use a model which has been developed for a specific injury to predict the outcome of a specific injury group than it is to use a model which has been developed for all kinds of injuries (Jones *et al*,1995). Some mistakes might have been made in measuring and coding the severity of injury variables because of human error. The quality of measuring and coding the severity of injury is important for the model prediction. The different factors might affect the validity of the TRISS model in the prediction of survival from road traffic injuries in Thailand. To predict survival of injured patients in Thailand, it would be better to calculate survival probability from the data of injuries from a database in Thailand. This is planned for up coming research.

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